Technology Opportunity

“Green” High Temperature Polymers

The National Aeronautics and Space Administration (NASA) seeks to develop and transfer “Green” High Temperature Polymer replacements for PMR-15. PMR-15 is a processable, high temperature polymer developed at NASA Glenn in the 1970’s principally for aeropropulsion applications. NASA Glenn has been conducting research for a replacement to PMR-15 that is environmentally friendly.

Potential Commercial Uses

- Aerospace
- Transportation - Automotive
- Manufacturing
- Chemical Industry - epoxy hardener, isocynates

Benefits

- Environmentally friendly high temperature (288 °C) polymers
- Stabilities and glass transition temperature comparable to PMR-15
- Reduced handling and disposal costs

The Technology

Use of fiber reinforced polymer matrix composites in aeropropulsion applications can lead to substantial weight savings, thereby leading to improved the fuel economy, increased passenger/payload capacity, and improved performance. PMR-15 is used fairly extensively in military and commercial aircraft engines components seeing service temperatures as high as 500°F (260 °C), e.g., the outer bypass duct for the F-404 engine. The current world-wide market for PMR-15 materials (resins, adhesives and composites) is on the order of $6–$10M annually.

PMR-15 is prepared with a monomer, methylenedianiline (MDA), which is a known animal and suspect human carcinogen. OSHA and the EPA heavily regulate the use of MDA in the workplace and require certain engineering controls be used whenever MDA containing materials, e.g., PMR-15, are being handled and processed. Implementation of these safety measures for the handling and disposal of PMR-15 materials costs the aircraft engine manufacturing industry millions of dollars annually.

Under the Advanced Subsonic Technology Program, researchers at NASA Glenn, General Electric, Maverick Composites, and St. Norbert College have been working to develop and identify replacements for PMR-15 that do not rely upon the use of carcinogenic or mutagenic starting materials. This effort involves toxicological screening (Ames’ testing) of new monomers as well as an evaluation of the properties and high temperature performance of polymers and composites prepared with these materials. A number of diamines have been screened for

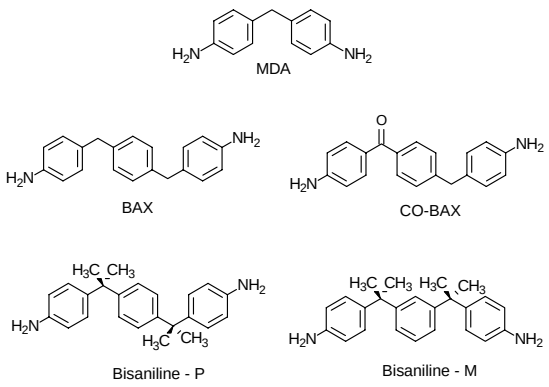

Figure 1.—Candidate replacement diamines for MDA (top) in PMR-15.

use in PMR-15 replacements. Four of these diamines, BAX, CO-BAX, Bisaniline P and Bisaniline M (Figure 1), passed the Ames' testing and show promise as non-MDA replacements for PMR-15.

Graphite reinforced composites prepared with polyimides containing these diamines were evaluated against a PMR-15 control in terms of their high temperature stability (weight loss after 3000 hr in air at 288 °C and 1 atm pressure) and glass transition temperature (an indication of high temperature mechanical performance). Results of these evaluations are shown in Figure 2. Further evaluation of the processability of these materials as well as their long-term stability and mechanical performance at 288 °C (550 °F) is in progress.

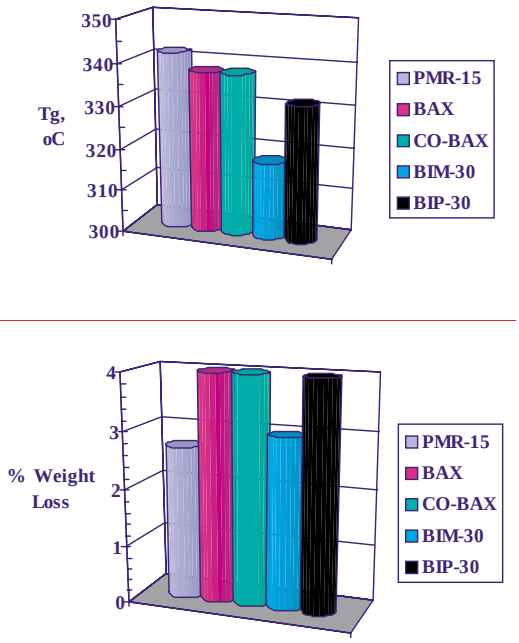

Figure 2.—A comparison of Tg and thermal-oxidative stability of graphic reinforced composites prepared with non-MDA PMR-15 replacements.

Options for Commercialization

While Bis-aniline-M and -P are commercially available, BAX and CO-BAX are not. Commercialization of BAX is currently being pursued under SBIR contracts with Triton Systems, Inc. and Maverick Corporation. Both of these companies are working on the development of low-cost, commercially viable routes to BAX. While the target cost for this diamine is less than $300/pound, it appears likely that these efforts will lead to substantially lower costs. NASA Glenn Research Center is currently looking for partners to further develop and commercialize these materials.

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